Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

A99.9
F764UN

United States
Department of
Agriculture

Forest Service

**Intermountain
Forest and Range
Experiment Station
Ogden, UT 84401**

Research Note
INT-325

December 1982

Recommendations for Selection and Management of Seed Orchards of Western White Pine

R. J. Hoff
D. O. Coffen[1]

Received: JYB
Indexing Branch

USDA
LIBRARY

ABSTRACT

Seed orchards of western white pine should be located on flat sites within the botanical range of western white pine. They should be planted at a 6 m by 6 m spacing, and they should be sprinkler irrigated, fertilized in August with 300 lb/acre ammonium nitrate, and sown with grass. Trees should be top pruned at 3 m and managed so that they develop three to four tops. Basal branches should be pruned to provide fire and rodent protection. A mechanical lift should be used to harvest cones when they are starting to open. Trees should be sanitized by removing all cones to decrease insect infestation. All trees should be tagged and the amount of pollen, number of cones, ripening day, and seed-germination capacity recorded for each individual tree.

KEYWORDS: seed orchards, western white pine, seed orchard management

The purpose of this paper is to provide recommendations on how to locate and manage western white pine seed orchards. Recommendations are based on data we have collected and experiences we have had in managing the Moscow Arboretum (an advanced breeding population used as a seed orchard) and the Sandpoint Seed Orchard. Data from other sources are used when pertinent. This paper is not an in-depth treatment of seed orchard technology. The reader is directed to the booklet on seed orchards edited by R. Faulkner (1975). Table 1 contrasts the two sites.

The Sandpoint Seed Orchard was established in 1960 with grafts of progeny-tested, blister rust-resistant parents (Bingham and others 1963). The grafts were made in 1959 and the orchard was planted in the spring of 1960. The purpose of the orchard was to provide seed for planting stock of western white pine resistant to blister rust. A secondary objective was to learn how to manage seed orchards.

The Moscow Arboretum was established from 1957 to 1961 and from 1964 to 1967 with western white pine seedlings that had survived intense artificial inoculation with blister rust. The purposes of the arboretum were to provide trees for advanced breeding for blister rust resistance, as a gene bank for resistance, as a source of seed for production planting, and for seed orchard management research.

[1]Plant geneticist and forestry technician, respectively, located at Intermountain Station's Forestry Sciences Laboratory, Moscow, ID 83843.

**Approved for publication by Intermountain Station
May 1982**

Table 1.—Contrasting factors that may reveal causes for differences of cone production between the Moscow Arboretum and Sandpoint Seed Orchard

Factors	Moscow Arboretum	Sandpoint Seed Orchard
Frost-free period	May 12-Sept. 6 (123 days)	May 18-Sept. 16 (121 days)
Precipitation	20 inches[1]	30 inches
Winter exposure	Open site with much wind damage	Protected, with little or no wind damage
Soil type	Palouse loess	Mission loam
Soil acidity	pH 7.8	pH 5.9-6.5
Ecological site	Natural grassland	Typical white pine type

[1]The Arboretum was irrigated from 1958 to 1968 and once again in 1976 following the winter drought of 1975-76. Irrigation water was the sewage effluent from the Moscow sanitation plant.

SITE SELECTION

Pick a site that is nearly flat within the best growing range of western white pine

A relatively flat orchard site will contribute to the availability of machinery for use in the orchard and to the safety of the workers. However, low level sites that do not have good cold air drainage should be avoided, as should sites with frequent downward movements of cold air. Adequate water must be available for irrigation and the site must also be secure from vandalism or Christmas tree cutters. A close labor source is a valuable asset.

Western white pine grows best and produces more cones (bigger cones with more filled seed) within the white pine type (Rehfeldt 1979; Hoff 1981). The average height of grafts at the Sandpoint Seed Orchard in 1979 was 9.5 m (31 ft); at the Moscow Arboretum, the average height of grafts of the same families was 7.3 m (24 ft) and the Moscow grafts were older. Sandpoint produced more than twice as many cones per tree as did the Moscow grafts (80 as opposed to 37).

SPACING

6 by 6 m (20 ft by 20 ft)

Trees at both the Moscow Arboretum and the Sandpoint Seed Orchard are spaced at 6 by 6 m (20 ft by 20 ft) and with pruning, as recommended below, would have a probable life of 40 to 50 years. This will likely be beyond the genetic lifetime of the seed orchard as it will probably be replaced by one with better genetic material.

This large initial spacing has made for ease in moving vehicles and equipment in the orchard. Moreover, a square or rectangular orchard enhances pollen distribution.

IRRIGATION

Sprinkler irrigation

Several orchards are using the drip method for irrigation (Wheat and Bordelon 1980). This method probably conserves water, but one advantage of sprinklers is that they can be used for frost protection. Western white pine flowers appear to be sensitive to frost (Bordelon 1978).

It is expected that irrigation will have a beneficial effect on seed production on dry sites. In 1977, a portion of the Moscow Arboretum irrigated during July of the harvest year produced 23,027 seeds per pound (10,445 per kg) compared to 26,309 smaller seeds per pound (11,934 per kg) from a nonirrigated portion.

FERTILIZER

Ammonium nitrate at 300 lb/acre Apply late August or early September

Fertilizer-irrigation studies were completed several years ago using the grafts at Sandpoint and the seedlings in a plantation near Fernwood, Idaho. The purpose was to initiate flower production. These fertilizer-irrigation treatments had no effect on cone production (Barnes and Bingham 1963; Steinhoff personal communication 1980).

Barnes (1969) did show that 300 lb of ammonium nitrate did increase cone production in trees that were already producing, and further, that the cones and seed were larger.

Schmidtling[2] believes fertilizing in August enhances photosynthesis, is too late to affect vegetative growth, and allows accumulation of carbohydrate and nitrogen favorable for flower induction. Fertilizing in September, he believes, is too late to affect either vegetative growth or carbohydrate accumulation before the formation of primordia. But, he says, the increase in nitrogen content is still partially effective in increasing flowering.

[2]Schmidtling, R. C. Fruitfulness in conifers: a critical review of the literature and recommendations for further research. 16 p. Unpublished report.

COVER CROP

Sow grass and keep it close cropped

A large rotary lawnmower will do a good job of keeping the grass low. We have also used horses (Coffen 1978). They did a good job and even ate thistles. However, on the orchard sites trees must be 15 to 20 ft tall; otherwise horses may damage the trees.

Grass will support vehicular traffic and, if cutting and growth periods are timed to produce competition for water, may be used to stress the trees in flower induction programs. Tall oatgrass was used in the Moscow Arboretum. However, Pomar dwarf orchardgrass and Durar hard fescue may be a better choice to control weeds and provide ground cover. At the Lone Mountain Plantation, Coeur d'Alene, Idaho, Pomar dwarf orchardgrass definitely had a positive effect in reducing gopher activity. Anyone wishing to use grass as a cover crop should check with the local Agricultural Extension Agent for the best grass variety for a particular area.

PRUNING

1. **Cut the leader during the growing season when the top whorl reaches 3 m (10 ft) (fig. 1A) and a 25-cm (6-in) stub can be left above the whorl (fig. 1B)**

2. **Each year, shape trees by removing only the terminal bud of any leader showing dominance (fig. 1C)**

3. **Manage trees to produce two to three stems from the 3-m height (fig. 1D)**

Trees in the Moscow Arboretum with multiple tops produce more cones and pollen than single-stemmed trees (Bordelon 1978; Coffen and Bordelon 1981). Also, trees with multiple stems in the top were not obviously shorter in height than single-stemmed trees. Blum (1980) reported that total tree height is not significantly affected by pruning. In his work on pruning softwood trees to improve wood quality, he found that removing less than one-sixth of the crown had not affected height or radial growth of trees after 9 years.

FIRE AND RODENT PROTECTION

Remove basal branches up to 2 to 2.5 m (6 to 8 ft) over several years

Remove the bottom two whorls the same year that the leader is cut (fig. 1B). Remove one whorl per year every 2 to 3 years thereafter. This will remove cover for rodents and fuel for disastrous fires. Ten to fifteen years after pruning, the orchard trees should look something like those in figure 1D as compared to an unpruned tree (fig. 1E). The basal pruning will also make it easier to move equipment around the orchard.

With the exception of increasing moisture stress in flower induction programs, the grass should be kept short enough to minimize fire risk. A firebreak should be established and maintained around the orchard perimeter. Maintenance of a short turf removes food and cover and acts as an ecological measure to limit the distribution of mammals, such as mice, ground squirrels, and rabbits, that feed on vegetative structures. Grazed or mowed grass makes it easier for avian predators to control pest populations. Kimbal and others (1970) report that the use of predators effectively controlled gopher populations around an artificial roost.

HARVEST

1. **Pick cones when they are spongy or just beginning to open**

2. **Extract seed immediately**

Not all cones mature at the same time. A 10-day to 2-week difference in the time of cone ripening among trees has been observed.

Cones collected during hot, dry weather provide seed with highest germination percentages, fastest germination, and minimal requirements for stratification. On the other hand, cones collected during cool and especially rainy periods behave differently. Even if cones were beginning to open, the process stops with the onset of cool weather. And if the cones are kept in burlap sacks, instead of being dried quickly, the seed coat may become infected with mold, which causes rotting during germination. We have controlled this mold to a degree by using a 10-minute soak in 5 percent solution of Clorox.[3] With such seed, it has been our experience that germination has been high but that the stratification process has to be just right; little variation in temperature or moisture levels has been tolerated. Further, cones and seed insects keep working until cones are dried and seed is extracted; so it is important to get extraction done as soon as possible.

In examining the importance of low seed moisture in pine, Barnett (1979) observed the following:

Seed moisture level	Response
Above 8 to 9 percent,	insects become active and reproduce.
Above 12 to 14 percent,	fungi grow on and in seed.
Above 18 to 20 percent,	heating may occur.
Above 40 to 60 percent,	germination occurs.

[3]The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others which may be suitable.

A. Unpruned tree.

B. Leader was cut when top whorl reached 3 m (10 ft). The bottom two whorls were pruned at this time.

C. Pruned tree 1 year after pruning.

D. Pruned tree several years after pruning.

E. Unpruned tree of comparable age to pruned tree shown in D.

Figure 1.—Method for pruning orchard trees of western white pine for maximum production of cones.

It has been our experience that collection of white pine cones at optimum ripeness gives maximum results in goal efficiency. Waiting until the cones are starting to open on the tree may cause some seed loss. However, we feel that some seed loss is preferable to the risk of carrying less than top-quality seed through the entire growing process. Loss of even 10 percent of the harvest is a better choice economically than finding that germination is low and being forced to double or triple sow to offset poor seed performance. Low-quality seed is also bad advertising for the orchard.

While the trees are fairly short, 6 to 8 m (20 to 25 ft), with short branches, the easiest way to pick cones is to climb the trees. Only the first 3 m (10 ft) are hard to climb and this can be eased with a ladder. When the trees are bigger, especially when they have multiple tops, a climber cannot efficiently pick cones; so the purchase of a mechanical lift is justified.

A good mechanical lift that we have seen is a track-wheeled machine operated from the bucket (fig. 2). It has a 40-ft lift to the bottom of the bucket, can operate on 15 to 20 percent slopes, and move around on 40 percent slopes.

Figure 2.—A mechanical lift such as that pictured greatly facilitates orchard work.

INSECT PROBLEMS

Remove all cones from the orchard each year, both from the trees and the ground

There are several cone and seed insects that parasitize western white pine cones. Some can be very destructive. One such insect, the ponderosa pine beetle (*Conopthorus ponderosae*), overwinters in cones, but can be controlled fairly well by removing all cones (a method also recognized by Hedlin and others 1980). The beetle nearly destroyed the entire crop (400 to 500 bushels) in the Sandpoint Orchard in 1978. However, good crops of western white pine cones are so frequent that the loss of a crop or two is not serious.

Orchards on sites remote from trees of the same species will be less susceptible to heavy invasion of cone and seed insects than those surrounded by natural stands. We still recommend placing a white pine seed orchard on a natural site because we expect to get more seed per dollar invested in a shorter time, even though we know nearly all seed will be lost to insects in some years.

TAGGING

Tag each tree with its identification and location

The identification number should be embossed on a large tag (6 cm by 6 cm or so) attached to a stake. Later, the tag can be affixed to the tree or hung on a branch. The purpose of the tag is to make sure the tree number can be seen easily so that data recording will be as speedy as possible. Stakes left in the ground often are destroyed by maintenance equipment.

Some plantation managers have used heavy gage wire, such as old telephone wire, as a stake after bending it to hold the label (fig. 3A). The label can be threaded into the wire circle on the stake and be attached to the tree when the tree is large enough to accommodate it (fig. 3B).

Tree identification by row, column, and entry into a computer is a great advantage for the manager. Finding a tree in the matrix, maintaining data records, or making forms for taking data becomes routine.

A. Metal tags on old telephone wire in ground.

B. Same tag transferred to tree at eye level.

Figure 3.—Method for tagging individual trees.

DATA COLLECTION

Tabulate the following data for each tree every year

1. Tally the number of cones just before harvest and the number of pollen clusters prior to flying or estimate numbers; for example, 1 = < 10, 2 = 11 to 30, 3 = 31 to 70, 4 = 71 to 100, 5 > 100 cones or pollen clusters. Reproductive capacity is family related, meaning that a very different population of seedlings may be produced than that planned (Bordelon 1978; Hoff 1978, 1981). This record, though expensive to obtain, is a necessary check on genetic balance from the orchard (for example, see table 2).

2. Record cone ripening time by day. Some trees are ready for cone harvest when others are still unripe. A quick examination of your data will give a list of trees with early cone maturation (table 3). Information like this is an important guide for managing field crews, as well as for manipulating seed quality.

Table 2.—Average amount of pollen and cones produced per ramet in the Sandpoint Seed Orchard in 1980

Clone	Ramets	Pollen[1]	Cones
		Number	
17	103	2.7	96
19	92	1.4	88
20	68	1.0	50
21	34	1.4	36
22	107	1.6	96
24	97	1.8	98
25	20	1.6	96
37	57	1.2	62
45	61	1.4	43
58	54	2.1	87
63	11	2.5	50
65	19	1.9	72
69	25	1.0	123
86	20	1.5	55
103	16	1.8	93

[1]Pollen categories were averaged; they were 1 = < 100 catkin clusters, 2 = 100 to 500 catkin clusters, 3 = > 500 catkin clusters.

Table 3.—Cone maturity on trees at Moscow Arboretum over 3 years

Maturity	Frequency	Percent
Early	112	8
Middle	891	62
Late	423	30
Total	1,426	100

3. Record germination ability. Seeds of some trees require no stratification, seeds from other trees need only to have the seed coat removed or clipped, and seeds from other trees need cold stratification (Andrews 1980). Since trees are picked individually, they could be combined according to similar seed-dormancy traits. Selection of combinations may really help the nursery phase of growing trees. For example, why stratify seed that does not need it or stratify seed for 100 days if it needs only 30?

4. Record the number of cones per bushel, seeds per pound, and percent of insect damage to cones and seeds. Such records can identify trees that are heavy producers, medium producers, or nonproducers, suffer high abortions, etc., and can provide information needed to plan fertilization, irrigation, and pest control (table 4).

Table 4.—1980 Moscow Arboretum seed crop evaluation; cones collected August 25–27, 1980

Bushel	Cones per bushel				Good seed					
	Good	Damaged	Destroyed	Total	Good cones		Damaged cones	Seed/ bushel	g/100	Seed/ml
	Number				Percent		Number			
1	95	40	6	141	3,630	93	726	4,362	2.05	22.0
2	71	61	13	145	3,010	74	1,054	4,064	2.10	21.5
3	41	39	8	88	1,740	56	1,360	2,100	2.20	20.0
4	49	28	3	80	2,117	64	1,176	3,293	2.30	17.6
5	96	52	6	154	4,141	70	1,734	5,875	2.20	20.4
6	95	29	3	127	4,576	76	1,456	6,032	2.10	20.8
7	141	2	0	143	7,548	99	44	7,592	2.00	22.2
8	101	22	23	146	4,643	88	639	5,282	2.15	21.3
9	89	25	11	125	5,100	91	500	5,600	2.25	20.0
10	101	24	9	134	5,217	90	588	5,805	2.20	23.5
$\bar{x}$	88	32	9	128	4,172	82	928	5,000	2.16	20.9

Seed production

Seed per bushel	5,000	Seed per ml	20.9
Seed per gram	46.3	Seed per pound	21,053
Seed per cone	39	Pound per bushel	.24
Cones per bushel	128		

Miscelleneous data

1980 germination = 77.8 percent
Insect-damaged or destroyed cones = 32 percent
Total harvest = 250 bushels
1980 estimated production = 300 bushels

PUBLICATIONS CITED

Andrews, D. Western white pine seed germination. In: Progress report. Moscow, ID: Inland Empire Cooperative Tree Improvement Program; 1980: 37–42.

Barnes, B. V. Effects of thinning and fertilizing on production of western white pine seed. Res. Pap. INT-58. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1969. 14 p.

Barnes, B. V.; Bingham, R. T. Flower induction and stimulation in western white pine. Res. Pap. INT-12. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1963. 10 p.

Barnett, J. P. Alternative methods for extracting southern pine seeds. In: Proceedings I978 Southern Nursery Conference. Tech. Publ. SA-TP6. Washington, DC: U.S. Department of Agriculture, Forest Service; 1979: 119-125.

Bingham, R. T.; Hanover, J. W.; Hartman, H. J.; Larsen, Q. W. Western white pine experimental seed orchard established. J. For. 61: 300–301; 1963.

Blum, B. M. Growth trends in pruned red spruce trees. Res. Note NE–294. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest and Range Experiment Station; 1980. 6 p.

Bordelon, A. Some environmental and genetic parameters of cone production in *Pinus monticola* Dougl. Moscow: University of Idaho; 1978. Thesis.

Coffen, D. O. Equestrian turf control in a white pine breeding arboretum. In: Progress Report. Moscow, ID: Inland Empire Cooperative Tree Improvement Program; 1978: 41–45.

Coffen, D. O.; Bordelon, M. A. Stem breakage effect on cone and pollen production in *Pinus monticola* (Dougl.). Res. Note INT–312. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1981. 6 p.

Faulkner, R. Seed orchards. Bull. 54. London: Forestry Commission; 1975.

Hedlin, A. F.; Yates, H. O., III; Tovar, D. C.; Ebel, B. C.; Koerber, T. W.; Merkel, E. P. Cone and seed insects of North American conifers. Washington, DC: Canadian Forestry Service; U.S. Department of Agriculture, Forest Service; Secretaria de Agricultar y Recursos Hidraulicos, Mexico; 1980. 122 p.

Hoff, R. J. How to stratify western white pine seed. In: Progress report. Moscow, ID: Inland Empire Cooperative Tree Improvement Program; 1978: 28–36.

Hoff, R. J. Cone production of western white pine seedlings and grafts. Res. Note INT–315. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1981. 4 p.

Kimbal, J.; Paulson, T. A.; Savage, W. F. An observation of environmental rodent control. Range Improvement Notes 15(2): 8–9; 1970.

Rehfeldt, G. E. Ecotypic differentiation in populations of *Pinus monticola* in north Idaho–myth or reality? Am. Natur. 114: 627–636; 1979.

Wheat, J.; Bordelon, M. Seed orchards of western Oregon, western Washington, northern California and British Columbia. Nisqually, WA: Industrial Forestry Association; 1980.

The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

The Intermountain Station includes the States of Montana, Idaho, Utah, Nevada, and western Wyoming. About 231 million acres, or 85 percent, of the land area in the Station territory are classified as forest and rangeland. These lands include grasslands, deserts, shrublands, alpine areas, and well-stocked forests. They supply fiber for forest industries; minerals for energy and industrial development; and water for domestic and industrial consumption. They also provide recreation opportunities for millions of visitors each year.

Field programs and research work units of the Station are maintained in:

Boise, Idaho

Bozeman, Montana (in cooperation with Montana State University)

Logan, Utah (in cooperation with Utah State University)

Missoula, Montana (in cooperation with the University of Montana)

Moscow, Idaho (in cooperation with the University of Idaho)

Provo, Utah (in cooperation with Brigham Young University)

Reno, Nevada (in cooperation with the University of Nevada)

☆ U.S. GOVERNMENT PRINTING OFFICE: 1982—676-032/28 Region No. 8